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► To cite this version:

Claire Cury, Roberto Toro, Fanny Cohen, Amel Mhaya, Dominique Hasboun, et al.. Characterization of Incomplete Hippocampal Inversions in a large dataset of young healthy subjects. Human Brain Mapping - 2015, Jun 2015, Honolulu, United States. hal-01212219

HAL Id: hal-01212219

<https://inria.hal.science/hal-01212219>

Submitted on 6 Oct 2015

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Characterization of Incomplete Hippocampal Inversions in a large dataset of young healthy subjects

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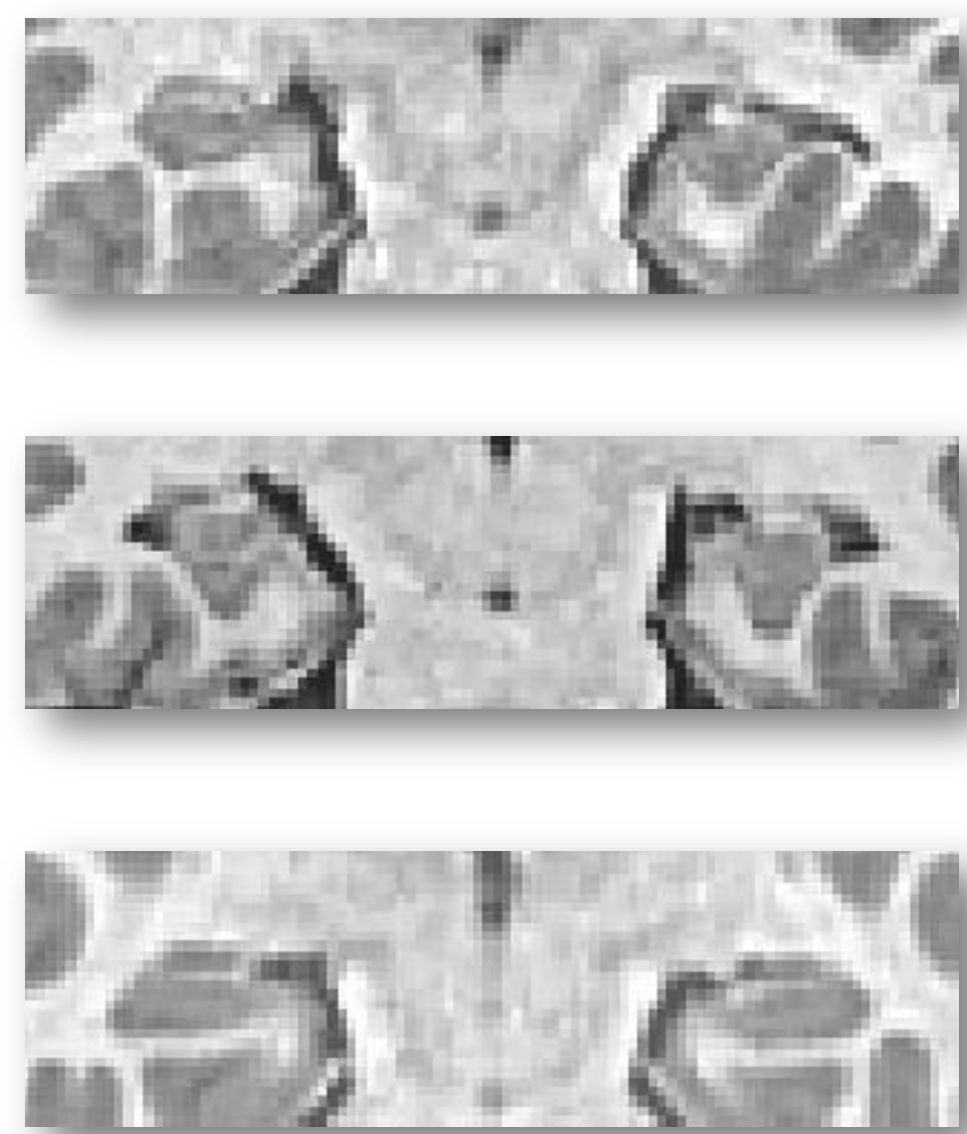
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INTRODUCTION

Incomplete hippocampal inversion (IHI) is an atypical anatomical pattern of the hippocampus.

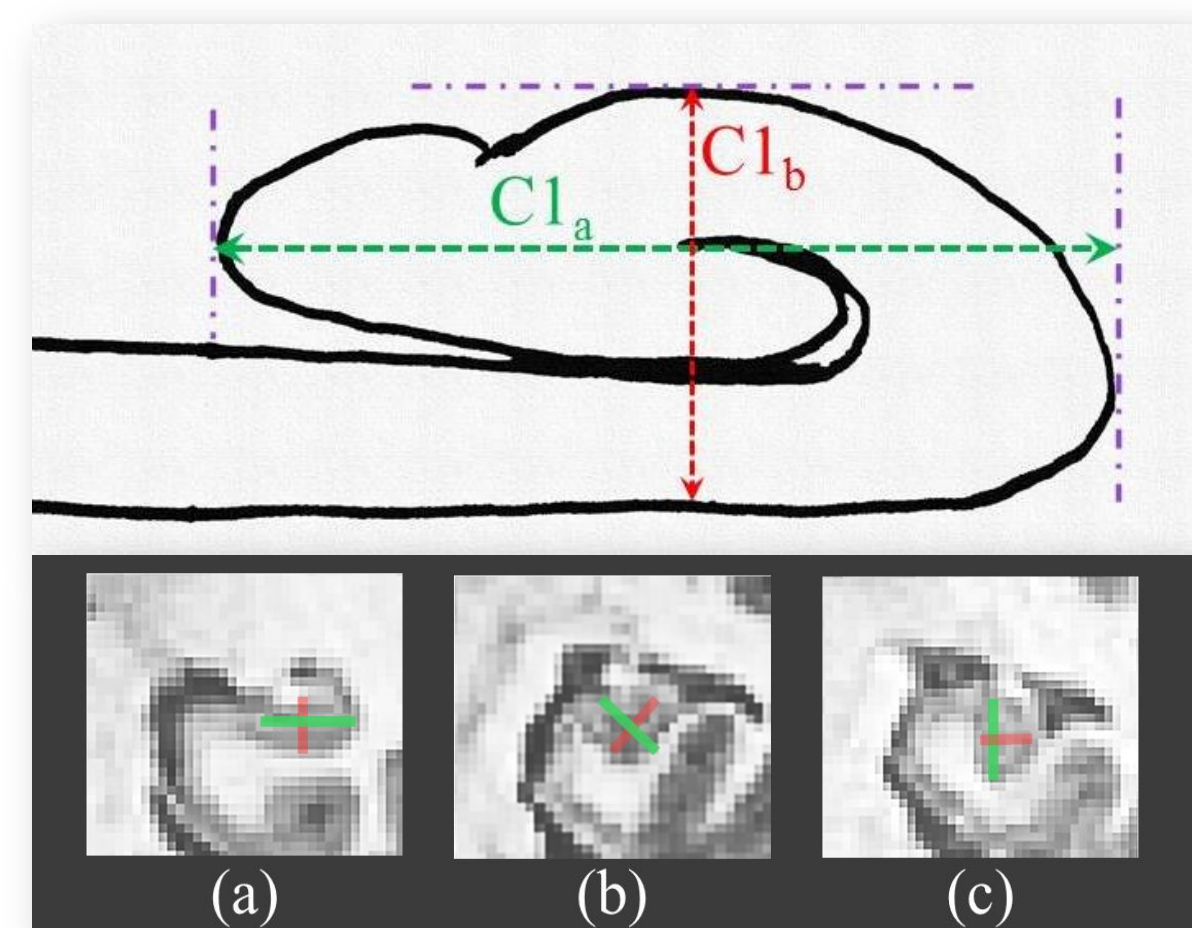
It has been mostly described in patients with epilepsy, malformations of cortical development and in temporal lobe epilepsy (Baulac et al. 1998; Bernasconi et al. 2005; Bajic et al. 2009), with a prevalence of 30%-50%. IHI are also found in healthy subjects, although with an apparently lower frequency (Bajic et al. 2008). However, these studies include a small number of subjects or included patients without epileptic seizures but referred for other neurological conditions.

The purpose of our study was to investigate the prevalence of IHI in a large population of normal subjects.

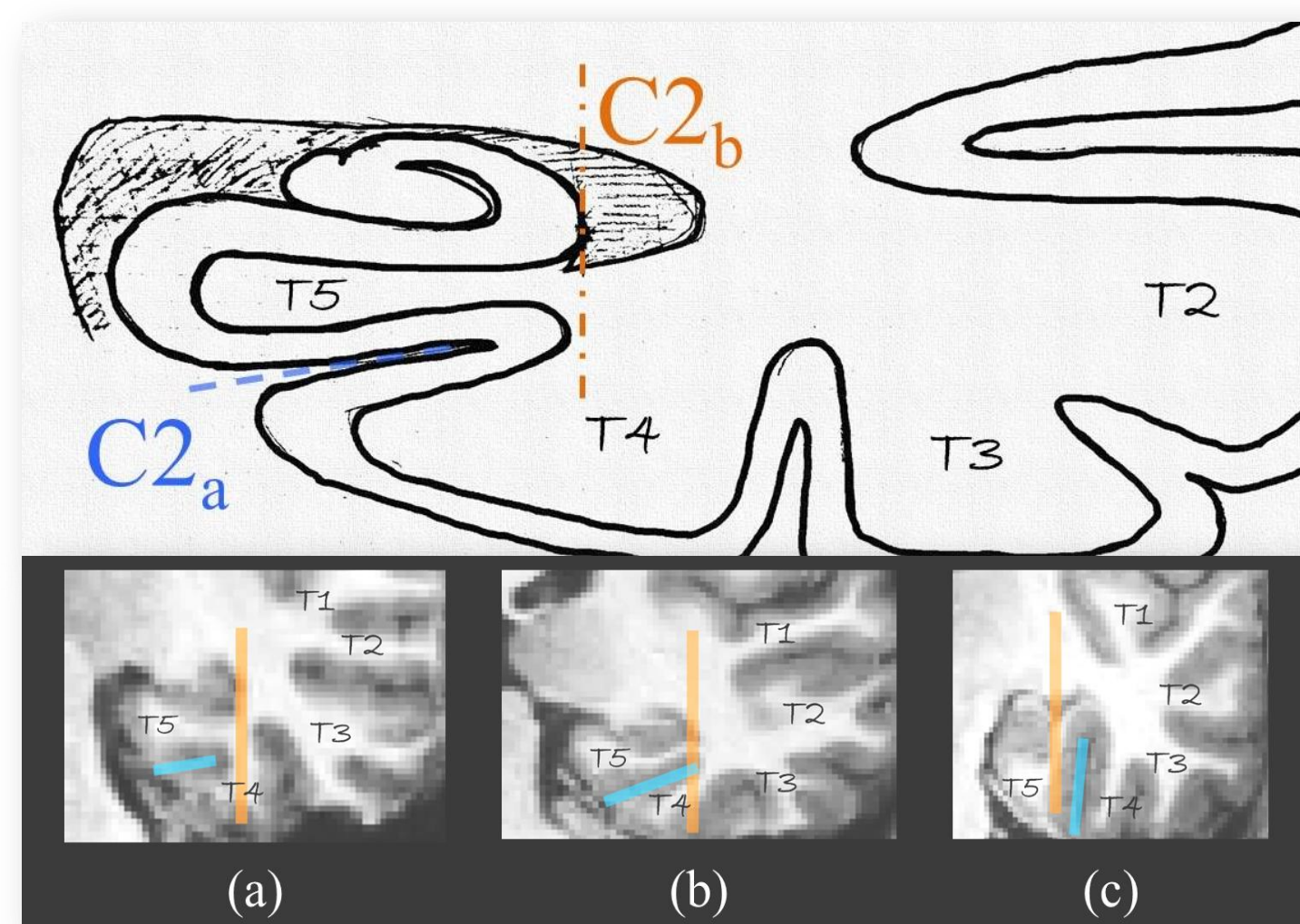


METHODS

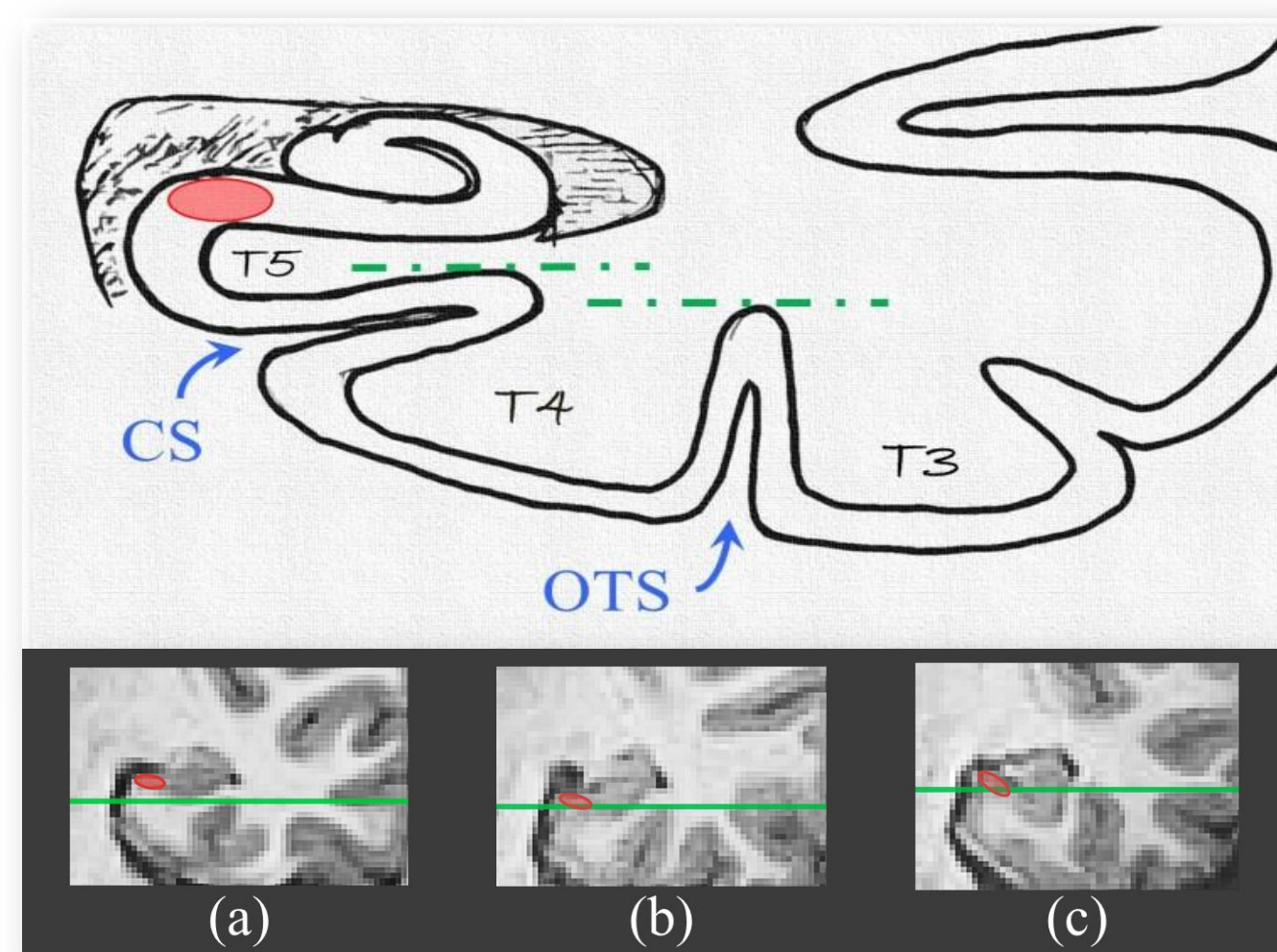
- We studied **2008 subjects** of the European database **IMAGEN** (Schumann et al. 2010). IHI was assessed using a **visual scale** on T1-MRI. We adapted existing criteria to make feasible the evaluation of a large dataset. Each criterion have a note between 0 and 2.
- A global **criterion C0** indicates the presence of IHI on the global aspect of the hippocampus: 0 if there is no IHI, 2 if there is an IHI and 1 if the IHI is not obvious.



criterion C1: roundness of the hippocampal body and its verticality. *Atypical if $C1_b \geq C1_a$ and $C1_a$ verticalized.*

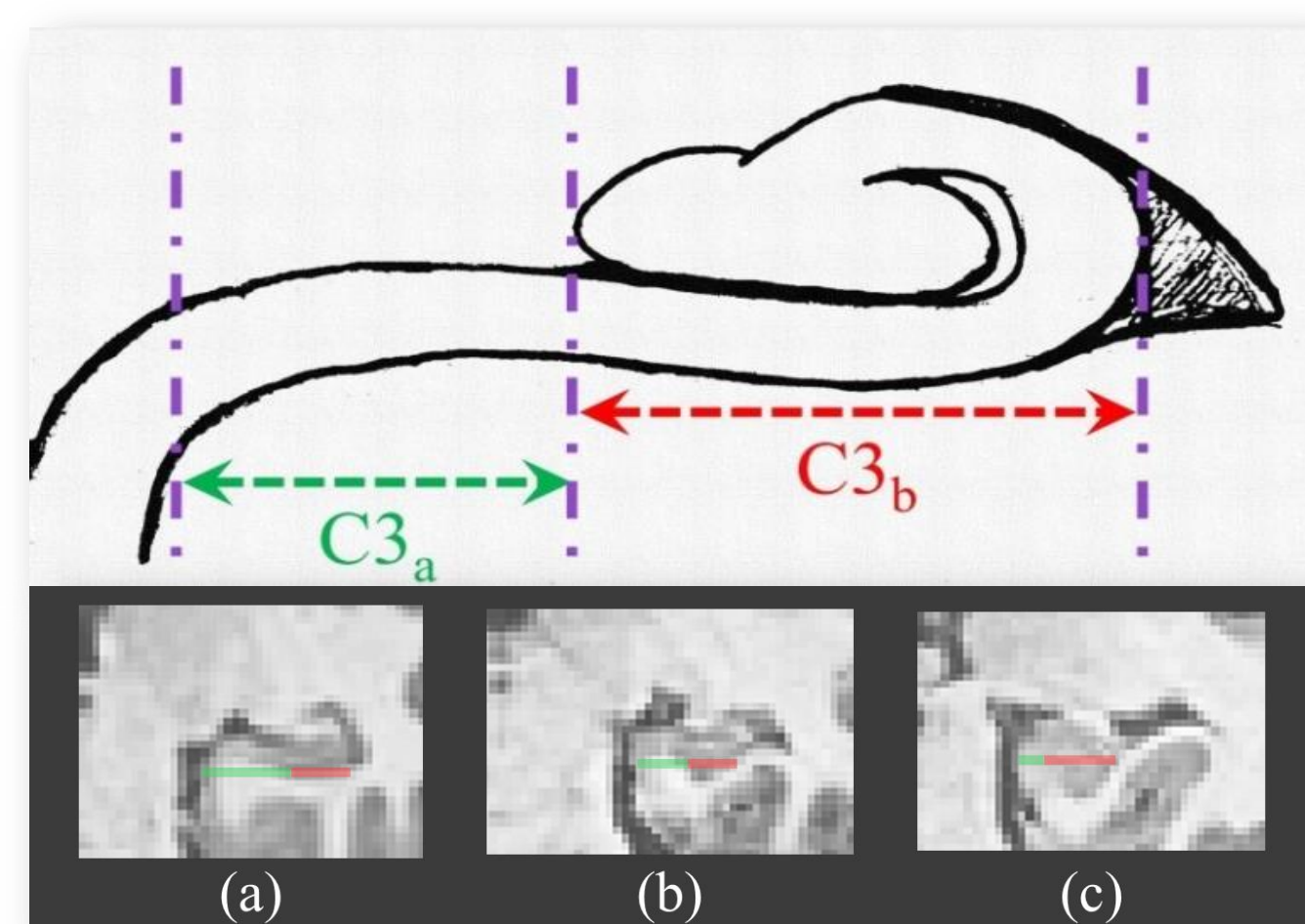


criterion C2: verticality and depth of the collateral sulcus relative to the size of the hippocampus. *Atypical if $C2a$ is verticalized and crosses $C2b$.*



criterion C4: thickening of the subiculum. *Red area*

criterion C5 evaluates if one of the sulci that limits the fusiform gyrus crosses the level of the subiculum. *Atypical if one of them crosses the subiculum.*



criterion C3: medial positioning of the hippocampus. *Atypical if $C3_a$ is short compared to $C3_b$.*

- The sum of individual criteria C1 to C5 to produce an **IHI score** between 0 and 10, indicating the degree of IHI.
- IHI of the hippocampi of the database were assessed by 2 raters (CC and FC). 42 subjects were randomly selected to assess intra- and inter-rater reproducibility.
- A kappa test were used to estimate the reproducibility of the criteria.

RESULTS

→ The reproducibility was beyond 0.64 (substantial agreement).

→ Very **strong agreement** (>80) were observed in the majority of cases

Frequency of IHI, according to the global criterion C0, for left and right hippocampi. Confidence intervals (CI) are at 95%.

C0	No IHI	Partial IHI	IHI
Left	70.9%	11.9%	17.1%
Right	84.6%	9.0%	6.5%

Left vs Right	No IHI Right	Partial IHI Right	IHI Right
No IHI Left	65.9%	3.1%	1.9%
Partial IHI Left	7.9%	3.5%	0.5%
IHI Left	10.8%	2.3%	4.0%

Results of Kappa test for the inter and intra reproducibility of the criteria

	C0	C1	C2	C3	C5
CC1 vs CC2	0.80	0.74	0.78	0.81	0.73
FC1 vs FC2	0.89	0.71	0.82	0.87	0.87
CC1 vs FC1	0.79	0.64	0.81	0.86	0.86
CC2 vs FC2	0.87	0.82	0.88	0.87	0.80

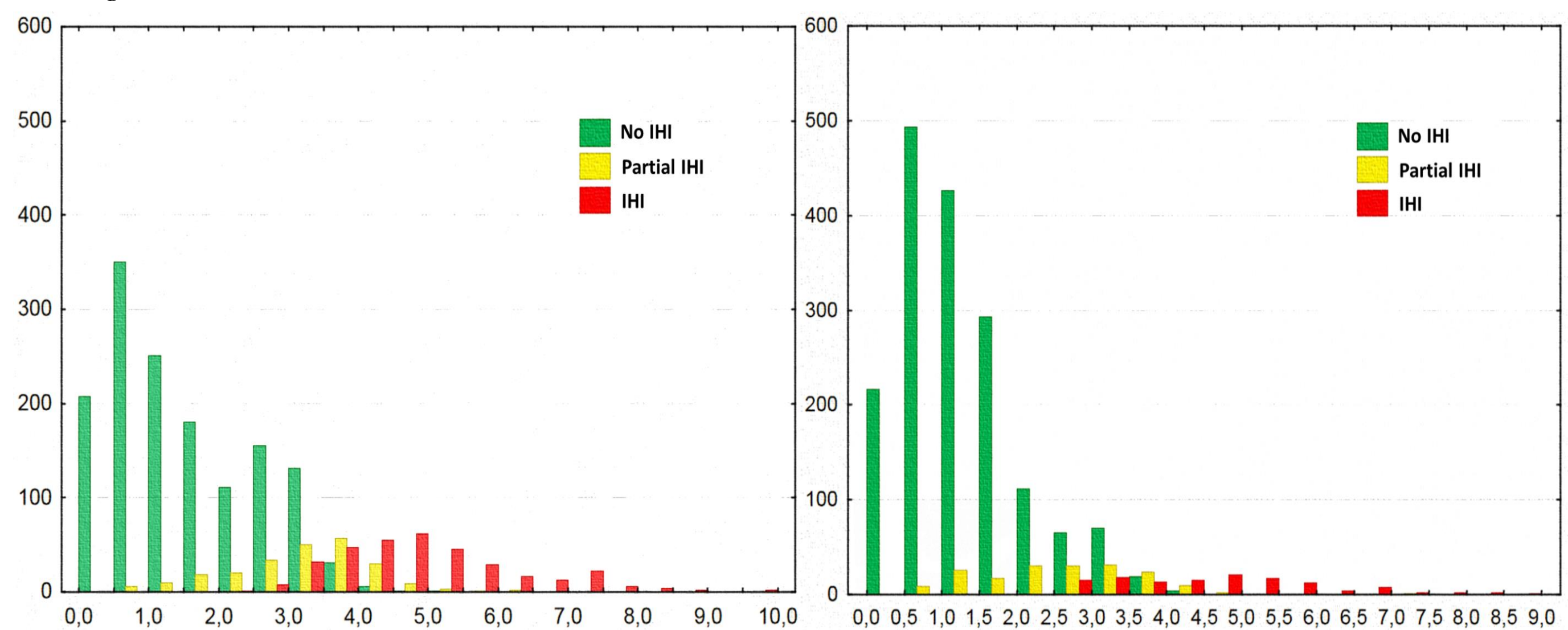
→ Based on criterion C0, we computed the frequency of IHI:

→ IHI were **more frequent** for the **left** than for the right hippocampus (χ^2 test = 129.2, $DF=2$, $p=8.5e-29$)

→ IHI did not differ between males and females nor depend on handedness.

→ The distribution of the total IHI score reflect a **continuous** spectrum of atypical patterns.

Histograms of the IHI score for left and right hippocampi. The colour indicates the value of the global criterion C0



CONCLUSION

- Our results demonstrate that IHI are a common phenomenon in healthy subjects. Thanks to the study of a large dataset of over 2000 subjects, we were able to provide reliable estimates of the frequency.
- We also proposed a visual scale of IHI that is applicable to large datasets.
- IHI were much more frequent in the left hemisphere.
- The IHI score shows a continuum between the absence and the presence of IHI, and therefore using a IHI score seems to be more adapted for the study of IHI than a global criterion.

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